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PHYTOTOXICOLOGY SURVEY REPORT

FORD MOTOR COMPANY OF CANADA

ESSEX ALUMINUM PLANT

WINDSOR (1992)

JANUARY 1994

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Abstract

Phytotoxicology Survey Report: Ford Motor Company of Canada
Essex Aluminum Plant - Windsor (1992)

The Essex Aluminum Plant produces aluminum components for automobile engines. A flux containing fluoride and Cl_2 gas are used in the process. Concentrations of HF and HCl in ambient air near the plant were measured by a mobile tandem mass spectrometer and were found to exceed Air Quality Standards.

This investigation used grass tissue samples as biological monitors of these air contaminants. Samples of grass were sampled at five locations along each of four transect lines originating at the plant and extending approximately one kilometer along the four cardinal compass bearings. Silver maple foliage was also sampled at some locations. These samples were subsequently analyzed for fluoride and chlorine.

The pattern of fluoride concentrations in grass samples indicated the Essex Aluminum Plant as the source of the fluoride. This pattern also indicated that the concentrations declined rapidly with distance. Most of the impact was within the industrial land buffer around the plant, although fluoride could encroach into nearby residential areas. Fluoride in silver maple samples were also elevated near the plant. The tissue concentrations were high enough to injure sensitive plant species.

The chlorine concentrations did not reveal a gradient around the plant. This was due primarily to high background concentrations and high natural variablity in plant tissue.

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1 Introduction

1.1 Essex Manufacturing, Essex Aluminum Plant

Essex Manufacturing is a partnership between Ford Motor Company of Canada Limited and Ensite Limited. The Essex Manufacturing facility is located at 6500 Cantelon Drive in Windsor, Ontario. This facility, also known as the Ford Essex Aluminum Plant, produces cast aluminum components for automobile engines. This facility will be referred to as 'Ford-Essex' in this report.

Aluminum scrap is melted in two rotary furnaces. A flux consisting of NaCl, KCl and $KAlF_4$ is used to prevent oxidation and remove impurities. The molten aluminum is transferred to holding furnaces and then to pouring ladles. While in the ladles, a mixture of chlorine (Cl_2) and nitrogen (N_2) gases is bubbled through the molten aluminum to remove dissolved gases that would create voids in the finished engine component upon solidification. This process is referred to as 'degassing'. The aluminum is then poured into moulds to form the engine components.

The rotary furnaces are vented through two baghouses to control particulate emissions. The Cl_2/N_2 degassing stations are vented to the atmosphere through two roof stacks. There are no controls on the gaseous emissions from this facility.

1.2 TAGA 6000 Air Quality Monitoring

In September, 1991, the Ministry of Environment and Energy (MOEE) mobile tandem mass spectrometer (TAGA 6000) conducted a survey in the vicinity of Ford-Essex to identify odours believed to originate at this facility. During the survey, gaseous hydrogen fluoride (HF) was detected at concentrations that exceeded the Air Quality Standard. Hydrogen chloride (HCl) was also detected at elevated concentrations (Reference 3).

The TAGA 6000 returned to the Ford-Essex facility between July 30 and August 11, 1992. During this period, 54 half-hour average concentrations of HF and 53 half-hour average concentrations of HCl were determined (Reference 2).

The Air Quality Standard for HF is 4.3 ug/m^3 based on a 30 minute monitoring period. Forty-eight of the 54 measurements (89%) exceeded this standard. Twenty of the measurements were at

least 43 ug/m^3; ten times higher than the standard. The highest 30 minute average was 190 ug/m^3. Concentrations in excess of 100 ug/m^3 were detected in the residential area west of Ford-Essex.

The Air Quality Standard for HCl is 100 ug/m^3, also as a 30 minute average. Seventeen of the 53 measurements (32%) exceeded this standard. The highest 30 minute average was 490 ug/m^3, measured in the residential area west of Ford-Essex.

1.3 Emission Stack Testing

As a result of the detection of excessive HF and HCl concentrations in the air by the TAGA 6000, Ford-Essex retained an engineering consulting firm, ORTECH International, to conduct tests on the stacks suspected of emitting these gases. The tests were conducted in November, 1992 on the stacks venting the two rotary furnace baghouses; and on the two stacks venting the various degassing stations.

The tests identified the baghouse stacks as the primary sources of HF and HCl emissions to the atmosphere. The average emission rates of HF from the baghouse stacks were about 100 times higher than from the degassing station vents. Emission rates of HCl from the baghouse stacks were about 12 times higher than from the degassing station vents (Reference 4).

2 Phytotoxicology Section Survey

Following the initial detection of excessive atmospheric concentrations of HF and HCl by the TAGA 6000 in 1991, the MOEE Windsor District Office requested that the Phytotoxicology Section conduct a survey around Ford-Essex. This survey would be conducted during the summer of 1992 and would use vegetation as a bio-indicator of the HF and HCl emissions.

2.1 Preliminary Reconnaissance

Phytotoxicology Section staff first visited the Ford-Essex facility on May 27, 1992. The plant is located in an industrial sub-division in the eastern part of the City of Windsor. Much of the land surrounding the plant building is owned by Ford-Essex or by the Ford engine assembly plant, located immediately south of Ford-Essex. Several fields in the area were in soybean production in 1992.

Other lands in the area are occupied by various manufacturing facilities, or are vacant. The nearest residential properties are located about 400 metres west of Ford-Essex.

There was a paucity of trees in many areas around the plant, suggesting prior agricultural use of the land. The trees that were present were of various species. There was not one species common to all parts of the intended survey area. This was significant because tree foliage of a common species is a desirable bio-indicator of point source emissions such as HF and HCl, and is the preferred material to examine and chemically analyze in a vegetation-based survey.

The only type of vegetation that had any reasonable probability of being at or near all potential sampling locations was grass. Consequently, grass tissue, or forage, was selected as the material that would be collected and chemically analyzed in this survey.

2.2 Survey Design

The survey design was developed on a 1:10,000 scale, Ontario Base Map (OBM) prepared from 1985 aerial photography and published by the Ministry of Natural Resources. A central point on the Ford-Essex plant building was marked and concentric circles representing distances of 200, 400, 600, 800 and 1000 metres were drawn around this point. Lines representing the four principal compass bearings (north, south, east, west) were also drawn from this point. The intersects of the arcs and lines were designated as target sampling locations.

A multiple transect-line survey design is suitable for an initial survey since it can delineate the dimension of the emission impact zone without prior knowledge of wind directions. Around Ford-Essex, transects of 1000 metres would extend through the industrial areas around Ford-Essex into the surrounding residential neighbourhoods.

The final step in preparing for the survey was to visit each target site and identify a suitable location for collecting a grass sample. Some of the target sampling locations could have fallen on unsuitable surfaces, e.g. pavement. Also, since grass grows from a basal meristem, mowed grass would consist of very

young tissue with a short exposure time to air contaminants. Consequently, a suitable location had to contain grass that had not been mowed recently.

Table 1 lists the Universal Transverse Mercator (UTM) co-ordinates of the sampling locations and the calculated distances and azimuthal bearings from the Ford-Essex plant. The sampling locations are designated with alphabetic and numeric characters representing the four principal compass bearings and relative distances from Ford-Essex.

TABLE 1: UTM Co-ordinates and Bearings and Distances from Ford-Essex of Grass Sampling Locations

LOCATION	NORTHING	EASTING	BEARING(°)	DISTANCE (m)
N1	4685120	0339830	345	196
N2	4685370	0339920	5	442
N3	4685510	0339960	8	585
N4	4685580	0339760	350	661
N5	4685880	0339750	352	959
E1	4684970	0340060	77	184
E2	4684930	0340240	90	360
E3	4684970	0340500	86	621
E4	4684920	0340730	91	850
E5	4684880	0340980	93	1101
S1	4684770	0339900	173	161
S2	4684570	0339870	182	360
S3	4684350	0339820	186	583
S4	4684130	0339910	178	801
S5	4683920	0339940	177	1012
W1	4684930	0339710	270	170
W2	4684980	0339500	277	383
W3	4684900	0339280	267	601
W4	4684870	0339120	265	762
W5	4684870	0338880	267	1002

Figure 1 consists of a street layout map compiled from an Ontario Base Map. The sampling locations are marked on this map.

At four of the grass stations, N3, E5, S4 and W2, silver maple trees were located nearby. The Phytotoxicology Section has considerable experience in the use of tree foliage in fluoride surveys. Data from the Ford-Essex samples could be compared with survey results from other sources of fluoride.

FIGURE 1:	Grass and Silver Maple Sampling Locations

2.3 Sample Collection, Processing and Analysis

The grass sample collection occurred on August 19, 1992. Collection involved locating suitable sample material, making a series of cuttings close to the ground, removing necrotic blades, flowering stems and foreign matter, and placing samples into labelled kraft paper bags. Duplicate samples were collected at each location.

The silver maple foliage samples were collected on August 20, 1992, by cutting a branch from the side of the canopy facing Ford-Essex, removing the leaves and placing them into labelled kraft bags. Duplicate samples were collected in this manner.

All samples were delivered to the Phytotoxicology processing laboratory where they were manually screened to remove any remaining undesirable material, dried in a forced-draft oven, and ground in a stainless steel, rotating-blade (Wiley™) mill to pass through a one millimetre screen. Flint glass jars with polyethylene lids were used to contain the processed samples.

The samples were forwarded to the MOEE Laboratory Services Branch where the material was analyzed for fluoride and chlorine using standard analytical procedures. In brief, the procedure for fluoride involved extracting the sample in a weak acid solution and measuring the fluoride ion by specific ion electrode. Chlorine was determined by X-ray fluorescence and represents the total chlorine concentration. Unless otherwise specified, reference to 'chlorine' in this report is to the element, not the gaseous molecule, Cl_2.

3 Survey Results

The results of the chemical analyses of the grass and silver maple samples, as means of the duplicate samples, are given in Table 2. This table also contains Upper Limit of Normal (ULN) concentration guidelines for fluoride and chlorine in grass and tree foliage. The ULN guidelines are explained in the appendix to this report.

The concentrations of fluoride and chlorine in the grass samples collected at all sampling locations are also represented graphically in Figures 2 and 3.

TABLE 2:	Mean Fluoride and Chlorine Concentrations in Grass Tissue and Silver Maple Foliage in the Vicinity of the Ford Essex Aluminum Plant, August, 1992			
LOCATION	GRASS TISSUE		SILVER MAPLE FOLIAGE	
	FLUORIDE (ug/g dw)	CHLORINE (% dw)	FLUORIDE (ug/g dw)	CHLORINE (% dw)
N1	10.6	0.81		
N2	2.6	1.35		
N3	1.3	1.25	6.8	0.16
N4	1.6	1.25		
N5	1.9	1.35		
E1	125.0	1.50		
E2	30.5	1.40		
E3	12.0	1.40		
E4	6.3	1.65		
E5	4.2	1.05	10.4	0.08
S1	72.0	1.25		
S2	16.5	1.60		
S3	10.9	0.74		
S4	4.2	1.65	12.5	0.14
S5	6.6	0.88		
W1	35.0	0.67		
W2	28.0	1.25	65.5	0.13
W3	7.7	1.20		
W4	6.5	1.04		
W5	1.8	0.53		
ULN* urban	not available	not available	35.0	not available
ULN* rural	12.0	1.00	15.0	0.15

* Upper Limit of Normal Guideline, see Appendix

Figure 2:

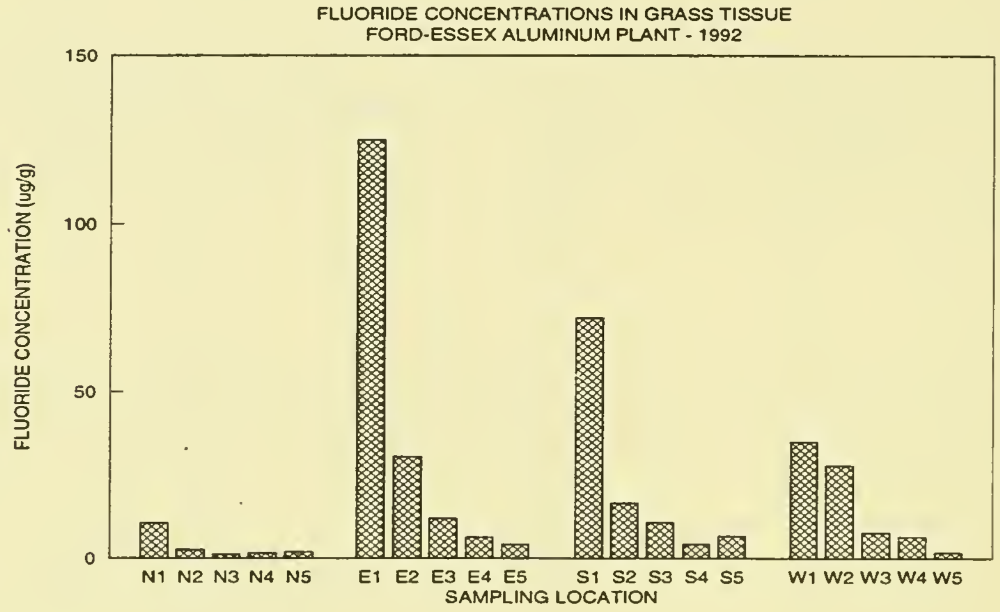
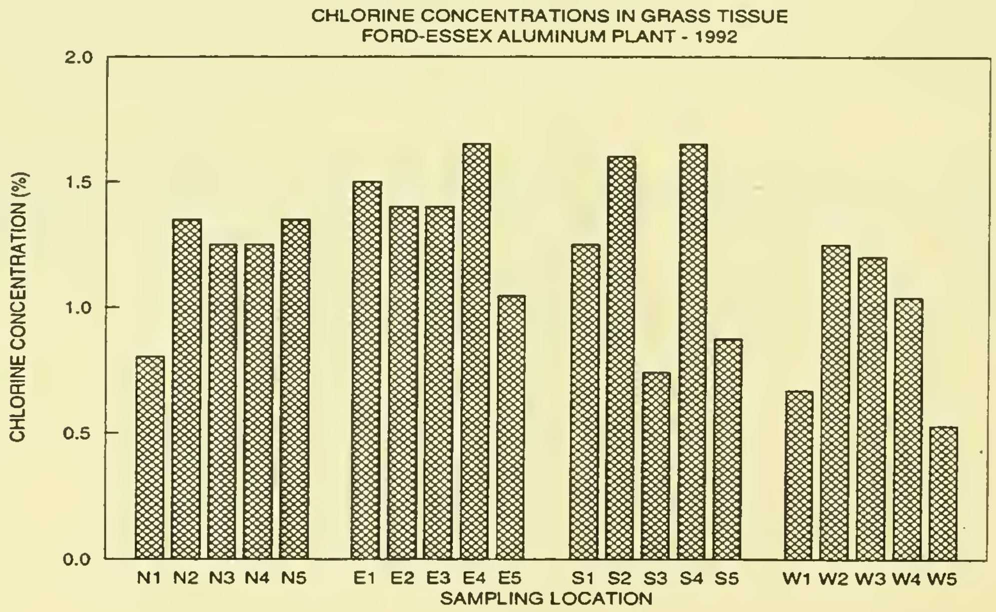


Figure 3:



4 Discussion

4.1 Fluoride in Grass Tissue

The concentrations of fluoride in grass samples collected at some locations were elevated. The highest concentration along each respective transect line occurred at the location closest to Ford-Essex. Figure 2 reveals progressively lower fluoride concentrations in grass samples at increasing distances from Ford-Essex. This pattern unquestionably implicates the Ford-Essex facility as the source of fluoride.

Figure 2 also reveals concentrations in samples collected along the N (north) transect to be considerably lower than those encountered along the other three transects at comparable distances. This implies that the grass tissue samples collected along the N transect were exposed to much lower air concentrations of fluoride.

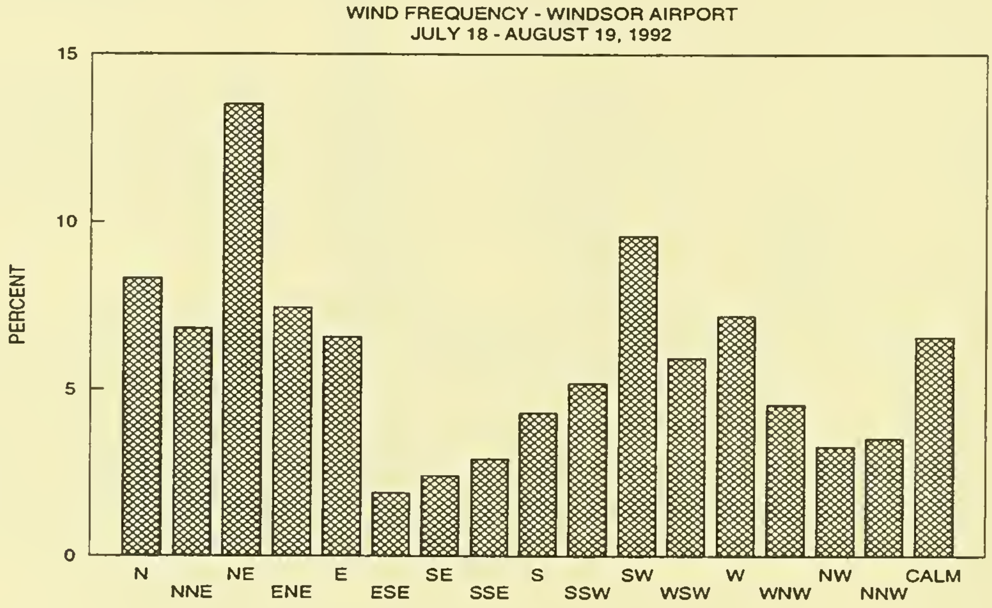
For this to occur would require a low frequency of wind from the south, or if winds from the south did occur, then the grass tissue would have to be in a physiological condition that would limit absorption of fluoride (e.g. periods of low light intensity or moisture deficiency, when stomatal opening would be restricted). This could also occur if, by chance, the rotary furnaces where not operating when southerly winds prevailed.

In an effort to resolve the uncharacteristically low fluoride concentrations along the north transect, when compared to the other transects, meteorological records from the nearby Windsor airport where obtained. Hourly prevailing wind data for the 33 days, July 18 to August 19, were compiled and frequencies from various directions calculated. The results are presented in Figure 4.

The period considered in this analysis requires some justification. The end of the period coincides with the sampling date. The beginning of the period is the date on which Ford-Essex resumed operation of the rotary furnaces following their shutdown on July 2 and 3. Consequently, grass tissue sampled in the vicinity of Ford-Essex on August 19 could potentially have been exposed to fluoride for a 33 day period. Because of the nature of grass growth, tissue that was exposed prior to the shutdown would constitute a small proportion of the August 19 sample. Grass continuously produces new tissue from a basal meristem

(growing point is at the base of the grass blade) and senesces from the tip. Therefore, most of the tissue present prior to the shut-down was either senescent and culled from the sample, or it was diluted by fresh tissue growth by August 19.

Figure 4:



The wind records show a relatively low frequency of southerly winds, considering southerly winds normally prevail. The underlying data to Figure 4 reveal a frequency of 12.4 % for winds from the south and adjacent (SSE and SSW) directions. Comparably calculated frequencies are; 18.7 % for northerly winds, 15.9 % for easterly winds, and 17.7 % for westerly winds. This analysis reveals that southerly winds were the least frequent. However, the difference in frequency between southerly winds and those from other directions does not explain the major differences in grass fluoride concentrations between the north and other transects.

To pursue further the incidence of low fluoride concentrations in grass tissue along the north transect would require detailed information on emissions from the rotary furnaces in the form of hour-by-hour production information, specifically flux usage. This would be compared to wind and other meteorological conditions at the time of the emissions. Such an analysis is beyond the scope of this report.

The primary conclusion from this part of the investigation is that Ford-Essex is the source of fluoride in the grass tissue. The fluoride gradients along the transects suggest a logarithmic decline in concentrations from this source. Because of the substantial land buffer around the Ford-Essex facility, the greatest impact of the fluoride emissions occurs on industrial properties, primarily those owned by Ford Motor Company.

However, the data show that fluoride can encroach into surrounding residential areas. The degree of such encroachment will depend on proximity to the source, as well as on wind directions.

4.2 Fluoride in Silver Maple Foliage

Silver maple foliage samples were collected at four locations in this investigation. The only location where foliar fluoride was clearly elevated was near W2. This location was also the nearest to Ford-Essex, along any transect line, containing a silver maple. Location W2 is in a residential area.

The foliar fluoride concentration in the silver maple near W2 was 65.5 ug/g. This tree is approximately 400 metres from Ford-Essex. This concentration is consistent, if not somewhat lower, than foliar fluoride concentrations encountered around other industrial fluoride sources (Reference 1). Foliar fluoride concentrations would have been much higher had suitable sample trees been present at the closer grass stations.

4.3 Chlorine in Grass Tissue and Silver Maple Foliage

Chlorine in grass tissue does not show any pattern with respect to the Ford-Essex facility. Figure 3 shows that concentrations vary considerably among the different sampling locations. They regularly exceed the rural ULN guideline. The chlorine concentrations in the four silver maple samples are very close to the rural ULN guideline.

Various investigations by the Phytotoxicology Section in southwestern Ontario have revealed high background chlorine concentrations in vegetation. The reason for this has not been confirmed. It does, however, preclude the use of vegetation in evaluating HCl emissions from Ford-Essex.

5 Conclusions

The Phytotoxicology investigation corroborates the TAGA survey conclusion that Ford-Essex is the source of fluoride in the atmosphere. The effect of the fluoride emissions, as defined by grass tissue fluoride concentrations in excess of the 12 ug/g rural ULN guideline extends to about 400 metres from Ford-Essex.

Concentrations of fluoride in grass tissue exceeding 80 ug/g in a single sample or averaging more than 35 ug/g over the growing season, would be unacceptable in a rural area since adverse effects could occur in grazing animals. Fortunately, Ford-Essex is located in an urban industrial area. However, fluoride concentrations of the magnitude encountered in this investigation are high enough to cause injury to foliage of sensitive plant species. This would be a concern in a residential community.

Although Ford-Essex also releases HCl, a vegetation-based investigation could not delineate the area of influence due to high natural background concentrations of chlorine in vegetation.

6 Recommendations

This investigation, while fulfilling its objectives, also uncovered certain inconsistencies. The foremost of these is the unusually low fluoride concentrations in grass tissue along the north transect. The collection of grass samples should be repeated in 1993. Tree foliage sampling should also be repeated and expanded.

Analysis of vegetation samples to identify influence of HCl emissions is impractical due to high background chlorine concentrations. Such analysis should not be repeated.

Considering the exceptionally high ambient air HF concentrations detected during the TAGA survey, the vegetation concentrations are unexpectedly low. Also, there were no obvious signs of injury to plants, although this survey did not include special efforts to locate or confirm such injury. A general survey for fluoride injury to vegetation should be conducted in 1993.

7 References

1. Gizyn, W. I., 1991, *Foliage Chemistry in the Vicinity of Allied Chemicals Canada Incorporated and General Chemical Canada Limited, Amherstburg, Ontario in 1988, 1989 and 1990*, Ministry of the Environment Report No. 91-2231-079

2. Karellas, N., 1992, Technical Memorandum, September 14, 1992

3. Ng, A., 1991, Technical Memorandum, October 2, 1991

4. ORTECH International, 1993, *Air Emissions Testing Program at the Essex Aluminum Plant, Windsor, Ontario*, Report No. 92-T62-B002704

8 Appendix

Derivation and Significance of the MOEE Phytotoxicology "Upper Limits of Normal" Contaminant Guidelines.

The MOEE Upper Limits of Normal (ULN) contaminant guidelines represent the expected maximum concentration in surface soil, foliage (trees and shrubs), grass, moss bags, and snow from areas in Ontario not exposed to the influence of a pollution source. Urban ULN guidelines are based on samples collected from urban centres, whereas rural ULN guidelines were developed from non-urbanized areas. Samples were collected by Phytotoxicology staff using standard sampling procedures (reference: Ontario Ministry of the Environment, 1989, *Ontario Ministry of the Environment "Upper Limit of Normal" Contaminant Guidelines for Phytotoxiology Samples*, Phytotoxicology Section, Air Resources Branch; Technical Support Sections NE and NW Regions, Report No. ARB-138-88-Phyto, ISBN 0-7729-5143-8). Chemical analyses were conducted by the MOEE Laboratory Services Branch.

The ULN is the arithmetic mean plus three standard deviations of the suitable background data for each chemical element and parameter. This represents 99% of the sample population. This means that for every 100 samples that have not been exposed to a pollution source, 99 will fall within the ULN.

The ULNs do not represent maximum desirable or allowable limits. Rather, they are an indication that concentrations that exceed the ULN may be the result of contamination from a pollution source. Concentrations that exceed the ULNs are not necessarily toxic to plants, animals, or people. Concentrations that are below the ULNs are not known to be toxic.

ULNs are not available for all elements. This is because some elements have a very large range in the natural environment and the ULN, calculated as the mean plus three standard deviations, would be unrealistically high. Also, for some elements, insufficient background data is available to confidently calculate ULNs. The MOEE Phytotoxicology ULNs are constantly being reviewed as the background environmental data base is expanded. This will result in more ULNs being established and may amend existing ULNs.